Universidade de Aveiro
2008

Departamento de Economia, Gestão e Engenharia Industrial

CATARINA ISABEL PEREIRA FERREIRA DA SILVA

Plano Pull com fornecedores
Pull Planning with suppliers

Universidade de Aveiro
2008

Departamento de Economia, Gestão e Engenharia Industrial

CATARINA ISABEL PEREIRA FERREIRA DA SILVA

Plano Pull com fornecedores
Pull Planning with suppliers

Projecto apresentado à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Engenharia e Gestão Industrial, realizada sob a orientação científica do Dr. José António de Vasconcelos Ferreira, Professor Auxiliar do Departamento de Economia, Gestão e Engenharia Industrial da Universidade de Aveiro

o júri

presidente

Prof. Doutor Luís Miguel Domingues Fernandes Ferreira
professor auxiliar convidado da Universidade de Aveiro

Prof. Doutora Maria Henriqueta Dourado Eusébio Sampaio da Nóvoa
Professora auxiliar da Faculdade de Engenharia da Universidade do Porto

Prof. Doutor José António de Vasconcelos Ferreira
professor auxiliar da Universidade de Aveiro

agradecimentos

Gostaria de agradecer ao meu orientador, Prof. Dr. José de Vasconcelos Ferreira, bem como, a todos os colegas da Bosch que contribuíram para o desenvolvimento desta dissertação.
Por último, deixo um agradecimento especial à minha família e amigos.

palavras-chave

Pull, Lean Manufacturing, TPS: Toyota Production System, Pull Planning, Supplier, VSM: Value Steam Method, Inventory coverage.

resumo

Pretende-se com este trabalho, Pull Planning nos fornecedores, abordar o conceito Pull e os princípios Lean directamente no fornecedor, para detectar problemas e definir acções correctivas. O Objectivo é preparar o fornecedor para a implementação de um sistema de pedidos em pull, permitindo melhorias ao nível da redução de inventário.

keywords

Pull, Lean Manufacturing, TPS: Toyota Production System, Pull Planning, Supplier, VSM: Value Steam Method, Inventory coverage.

abstract

The purpose of this work, Pull Planning with suppliers, is to approach the Pulll concept and the Lean principles directly to the supplier, in order to detect problems and define corrective actions. The target is preparing the supplier to implement a pull planning system, allowing improvements in inventory coverage reduction.

"Necessity is the mother of invention"

Victor Hugo, 1852

Index of Contents

Index of Figures

Index of Tables

List of acronyms and abbreviations

BPS – Bosch Production System

CI – Continuous Improvement

CIP - Continuous Improvement Processes

COS – Case Study Supplier

COT – Change Over Time

CT – Cycle Time

EMR – External Milk-Run

FIFO – First-In First-Out

FPS – Ford Production System

FTE – Full Time Equivalence

JIT – Just In Time

JIS – Just in Sequence

LOG – Logistics

LT – Lead Time

MR- Milk-Run

MRP- Material Requirements Planning

MSL – Maximum Stock Level

OEE – Overall Equipment Effectiveness

PPM – Parts Per Million

SAP – System Analysis and Program Development

TPM – Total Preventive Maintenance

TPS – Toyota Production System

TT – Takt Time

VSD – Value Stream Design

VSM – Value Stream Method and Mapping

Glossary

A3 Report: Toyota has a policy that all reports, no matter how important, should be presented on a single side of A3 paper. The idea being that ‘less is more’, meaning there is no value in individuals crafting large documents and others reading them if the information can be contained in something far smaller. The rest of the document is considered waste.

ABC Analysis: Analysis of a range of items that have different levels of significance and should be handled or controlled differently. It is a form of Pareto analysis in which the items (such as activities, customers, documents, inventory items, sales territories) are grouped into three categories (A, B, and C) in order of their estimated importance. 'A' items are very important, 'B' items are important, 'C' items are marginally important.

Cycle Time: this is time required to complete a cycle of an operation. The cycle times of interest are usually: the time taken to develop and release a new product, the time taken to make a user story production ready; and the time taken to get a release of an application into a live environment. Measuring and monitoring cycle times are key to driving the elimination of waste.

Five S’s: these are 5 terms that all begin with the letter ‘S’ that are intended to make your work environment suitable for Lean. Japanese is origin, they are, with rough English translations also starting with ‘S’ in brackets, *Seiri* (Sort), *Seiton* (Set in order), *Seiso* (Shine), *Seiketso* (Standardize) and *Shitsuke* (Sustain).

Heijunka: creating a ‘level-scheduling’ system to cope with short-term variations while planning for long-term demand

***Jidoka* (Automation):** machines are given ‘human intelligence’ and are capable of detecting and preventing defects. Machines stop automatically when defects are found, asking for help. This concept was pioneered by *Sakichi* Toyoda with his automated looms.

Kaizen: literally translates to ‘continuous improvement’ in English. A business philosophy of reducing continuous costs, reduce quality problems, and delivery times through rapid, team-based improvement activity.

Kanban: translates to ‘card’ in English. These are used to create ‘pull’ systems by acting as replenishment triggers to upstream process steps. It often uses a standard container with a card attached that is pulled when the container is moved by the using work center. After removal the card is used by the feeder work center as authorization for more production.

Milk-Run: The combination of shipments from multiple vendors in close geographic proximity into one shipment received by the customer, normally done for a defined route on a recurring basis.

Muda: translates to English as ‘waste’ and is defined as any activity that consumes resources but adds no value.

Mura: a traditional Japanese term for unevenness and is often also translated as inconsistency. An example is a variation in the pacing of an operation that involves the person performing it to hurry to finish an operation and then wait.

Muri: Exertion, overworking (a person or machine), unreasonableness.

Pacemaker: a process point within the value stream that sets the pace for the entire stream and maintains takt time.

Supermarket: a small storage area that often appears at the boundary of push and pull systems that allows the amount of stock to be visually regulated, often using calculated minimum and maximum levels. In a supermarket, a fixed amount of raw material, work in process, or finished material is kept as a buffer to schedule variability or an incapable process. A supermarket is typically located at the end of a production line (or the entrance of a U-shaped flow line).

Takt Time: the heartbeat of a lean system, this is used to set the rate of production to meet the rate of customer demand. It is the available production time divided by the rate of customer demand. If the customer wants 6 new online products released every 6 months then the takt time is one month. If customer demand is 20 story points per iteration and the team operates for 10 days within an iteration, then the takt time is 0.5 days.

Value: a capability provided to a customer at the right time at an appropriate price that is defined by the customer.

Value-Add: a value-add process step is one that transforms or modifies the product in such a way that a unit of value is added from the perspective of the customer.

Value Stream: the set of activities required to analyze, design and build a product from concept to launch.

Value Stream Mapping: a tool used to identify all of the process steps within a value stream for a given product. The value stream map can be used to identify process improvement opportunities, for example by documenting instances where the time taken for value-add activities can be reduced, non-value-add process steps can be minimized and waste can be eliminated.

WIP (Work In Progress): any work that is not completed but that has already incurred a capital cost to the organization.

1. Introduction

1.1. The scope

The University of Aveiro, and more specifically, the Economics, Management and Engineering Department, provided the Bologna Master in Industrial Management and Engineering. In cooperation with this Master, Bosch Termotecnologia SA contributed to achieve the practical studies.

The main purpose of this project is to develop a report based on scientific knowledge applied to the business world. Through this point the student will apply scientific knowledge in a practical case, showing the skills on research, analytical points, critical spirit and reasoning, of which the climax will be reflected on the practical solving of a case.

With this work I intend to develop my own capacities in scientific investigation, and at the same time apply them in industrial business. To accomplish the latter, this study will be focused on subjects that surround the daily operations of which the main scope is working with suppliers to get what the company needs to be productive and profitable. For that, the target of this thesis will be the implementation of Pull Planning with suppliers to get the best results for the company as quickly as possible.

1.2. The subject

A company that works in pull system should consequently extend it to the suppliers. Why is this important? Assuming that a pull system is one of the great lean principles and that the manufacturing system leads the company into producing what the customer wants, it’s very important that the company’s suppliers work with the same standards and in the same scope. The bridge between the company as customer and the supplier will be the way of ordering incoming parts and raw materials. If a company works in a pull system delivering the final product to the client just when it wants, then it must receive the material from its own suppliers when it needs it. Thus, the importance of having the suppliers working according to pull plans is the right way to walk through continuous improvement and adopting the lean principles in the value stream.

1.3. Report organization

As a starting point, the introductory chapter of this report is like a brief guide to the following chapters' development.

The second chapter is a literature review that includes a historical framing of pull and lean systems followed by scientific and technologic analysis. It's possible to acquire useful information/knowledge for the core chapter comprehension, the case study, but also give us the supplier relevance and how can we deal with them. Why should the pull aspects be implemented by suppliers?

The third chapter is the case study where the core business and main target points of Bosch Termotecnologia SA, from now on just called Bosch, will be described. The several efforts done to accomplish the pull planning of suppliers will be focused, and the relationship with principal suppliers too. Finally, the challenge that I'm proposing to have the pull planning working in one of Bosch's suppliers will be identified in this chapter.

Chapter four is the methodology part of this work where a schedule will represent the evolution of practical steps that will lead to the fifth chapter, results discussion. Here I am going step-by-step to show how to move in supplier house and how the pull system can be extended to the supplier. A set of tools is used to obtain results and improvements and the main ones will be explained. Some advantages and benefits are mentioned and a detailed analysis as a discussion of results will be made throughout the fourth chapter.

Finally, the conclusion chapter is where I will verify if the main targets were or were not reached, and if they really brought what I expected. This chapter also includes some points to continue improving business with suppliers.

2. Theoretical framing

2.1. Historical framing

Is it right saying that everything that leads to pull systems starts with the Toyota Production System?

If you want to understand the Toyota Production System (TPS), it is important to appreciate just how difficult it was to develop and manufacture the "perfect loom" (first branch of Toyota's business).

In 1945, Kiichiro Toyoda had challenged his company to "catch up with America". Unfortunately, Toyota was quite far from that because it couldn't adopt America's production model – mass production. America was producing thousand of similar parts (mass production) to gain economies of scale. In Japan, Toyota just simply couldn't have the same production model for many reasons: scarce material resources, poor orders and unstable demand. Economies of scale weren't available for Toyota! Thus, rose the idea to have material/parts used on assembly just before the assembly line. Parts should be made just before they are needed was Kiichiro Toyoda's vision, or as we now call Just-in-Time, (Magee, 2008).

Taiichi Ohno was a machine shop manager who embraced Toyoda's vision and decided to develop this challenge, thus giving the origin to the Toyota Production System. He flew to America and studied Ford's production system and realized that they were still working in mass production. Although Ohno learned an essential methodology in America, namely, the way of American supermarkets handled inventory. From the idea of a supermarket to years of experimentation, Ohno gradually developed the Toyota Production System, a process that he considered never-ending.

Until the oil crisis of 1973 the Toyota Production System was ignored as companies were growing swiftly and the sales were increasing. When the economy slowdown was triggered by the oil crisis, Toyota emerged from this crisis quickly. Toyota was used to producing just what was needed and had learned to optimize the processes. Other Japanese companies started to study the

TPS model and many of its features were adopted. Within a decade America and Europe began to see serious competition from Japan.

The great basis of TPS is the total elimination of waste and two pillars support it:

- Just-in-time
- Automation with a human touch (automation) (Womack, 1991)

It is important to note that the concept of Just-in-Time was completely against the conventional wisdom of that time. Although the resistance to Ohno's efforts was tremendous, he succeeded and Just-in-Time is today regarded as a maxim. The JIT flow means the elimination of general inventory, especially the stock in process. In other words, the right parts needed in assembly would reach the assembly line at the time they are needed and only in the amount needed, (Womack, 1991). The point is making everything in small batches with minimum inventory levels. In order to do this it’s necessary to have flexibility on the machines (low changeover) and perfect flow between the processes of the entire value stream. With automation, also called *Jidoka* (glossary), it’s possible to detect anything that goes wrong on the machine and consequently shut it down automatically. Having this kind of automation, Toyota could instantly detect errors in production without using special operators to observe it. Another advantage was zero inspection since the system was designed to be mistake-proof. So any mistake couldn’t reach any further. On figure1 it’s possible to have an overview of the TPS model.

In 1990 the book “The Machine That Changed the World” brought a new concept for what was previously called Just-in-Time or the Toyota Production System. Toyota's approach to manufacturing would become known as **Lean Production**. And from then on this concept began to gain power. Many companies attempted to adopt Lean Production, but it proved remarkably difficult. Lean thinking has moved from manufacturing to other operational areas with diverse scopes. Lean principles have also been extended to the supply chain, from product to supplier development.

Lean manufacturing is today taken as a set of standards of efficiency and effectiveness. In fact, using lean principles in manufacturing can bring a significant competitive advantage that can be unbelievably difficult to copy.

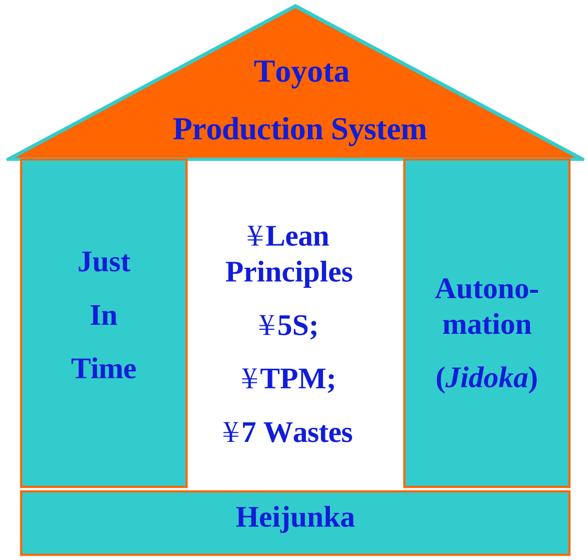


Figure 1: TPS House.

2.2. Lean Tools – Pull System

When pull is mentioned there is another concept that is associated with it, i.e. the lean process. Lean is used to describe a narrow set of tools, often restricted to production activities rather than a higher-level way of thinking about value stream. The very first point of lean is that it is a way of thinking, a philosophy. This type of thinking always starts with the desires of the customers. As already stated in this report, the lean manufacturing was introduced by Toyota Production System and it has been introduced to many big companies over the years. The concept target is to reach a lean production or, in another words, to produce only what the customer needs. For that, in general lines lean production:

- Stands for associates that think, decide and act in teams;
- Stands for efficiency increase by standardization and continuous improvement;
- Is a philosophy that leads to low waste processes in the company;
- Stands for delivery service, quality orientation and cost reduction;
- Looks at processes inside the company and out, including, the supply chain;
- Applies pull principles, especially by means of Just-in-Time delivery.

Lean manufacturing has several principles developed by TPS and by applying these principles we can discover the problems/deviations, describe them, and figure out all root causes. After that, we will be capable to gather, rate and select ideas to eliminate the root causes and experiment with ideas and measures, which will be judged by their effectiveness. In case of insufficient effectiveness we must go back and find out other rout causes and new measures until effectiveness is achieved. In the end, it's possible to implement improved procedures as the new standard. With this circle the continuous improvement is always possible and the waste in the systems can always be eliminated (Ohno, 1988).

Therefore, the first step of any lean thought process is to be crystal clear as to what the customer really wants (Jones, 2003). To achieve this objective it is necessary to work in some main processes and, generally, it's a combination of results between different processes, for instance, product development, order delivery, and price-cost relationships. If we gather these processes with the following characteristics, then we are working according to lean philosophy:

- Valuable: the customer is willing to pay.
- Capable: reach good results every time.
- Available: operate whenever needed.
- Adequate: have the capacity to produce in continuous flow.
- Flexible: a range of products can be produced without batching and delays.

All these characteristics can only work together when they are linked by:

- Flow: this allows the good or service to proceed immediately from one step to the next without stopping.

- Pull: to allow the downstream step to obtain just what it needs from the next upstream step whenever continuous flow is interrupted.

- Levelling: to smooth the operation of the process while still addressing the needs of the customer.

The actions above provide lean processes, however, they don't happen accidentally. People are needed and they are a crucial factor. To proceed in the lean thinking way it is necessary to make someone responsible for each value stream, (www.lean.org, 2008). Only in this way we can create value for the customer and we are using the so-called deployment strategy. This strategy frequently leads to improvement cycles for each process, embodying value stream maps many times demonstrated by A3 analysis. A3 analysis is a very powerful tool used as the basis of many projects.

We can define value as what is recognized by the customer and the value stream as the process or the string of steps in which value is added by the company. The value stream stretches all the way back through the suppliers and all the way forward to the customers, (www.worthsolutions.com, 2008).

Approaching the subject of this report with lean thinking means that we should let the customer "pull" the value. If the customer doesn't want anything, why are we wasting resources guessing what they might want? A good way to demonstrate the pull system is by observing how a supermarket works, just like Ohno did. For example, a customer pulls a *Super Bock* tin from a shelf that can be replenished from the warehouse in the back. The warehouse is replenished from a regional distribution center and that center is replenished from the *Unicer* distributor.

In other words, when an order is received, the pull should trigger a specific shipping date to satisfy the customer and then drive a production schedule to replenish the stock. This is working backwards, starting the process according to the schedule and keeping the components and assemblies moving down the value stream without delay.

The pull system is a simple visual method of automating stock replenishment of finished goods, intermediate components and raw material. The aim of such a system is to achieve 100% delivery performance in both quantity and timing. And for that reason the performance of suppliers is critically important!

There are three basic types of pull systems in production: the consumption control or supermarket; synchronous production (just in sequence); and a mixed pull system with elements of the previous two combined. In trivial lines here are those definitions (www.sme.org, 2008).

Supermarket Pull System

The most basic and widespread type is known as a fill-up or replenishment pull. In a supermarket pull system each process is a store, or a "supermarket", that holds a specific amount of each product it produces. Each process simply produces to replenish what is withdrawn from its supermarket. In a Lean system we normally want to schedule production at one process. This process is called the pacemaker and is normally towards the end of the line or, sometimes, at the final assembly. The basic idea is that we schedule production at this pacemaker allowing it to then “pull” material to it. With consumption control, the pacemaker is decoupled from the upstream process by supermarkets. A key rule for selecting the pacemaker is that all processes after it must “flow” to the customer. In a supermarket pull system the use of supermarkets prevents overproduction of items by specifying the maximum number to hold.

Sequential Pull System

In a sequential pull system the right quantity is produced and delivered in the right order of sequence and at the right time. JIS (just in sequence) can be used when there are too many part numbers to hold inventory of each supermarket. In a sequential system, the scheduling department must set the right mix and quantity of products to be produced. The pacemaker process on this kind of system will set the production sequence.

Mixed Supermarket and Sequential Pull System

The supermarket and sequential pull system may be used together in a mixed system. A mixed system can be appropriate when the 80/20 rules apply. The rule is based on the small percentage (approximately 20%) of part numbers and the majority (approximately 80%) of daily production volume. Often an analysis is performed to segment part numbers by volume, e.g. ABC analysis (glossary). Such a mixed system can be applied selectively and the benefits of each one are obtained, even in environments where the demand is complex and varied. With this system we can easily produce “make-to-order” and “make-to-stock”.

In these three cases the important technical elements for systems to succeed are:

- Following the product in small batches and high frequency.
- Pacing the processes to *Takt* Time (glossary) to stop overproduction.
- Signalling replenishment via a Kanban (glossary) signal.
- Levelling (glossary) of production mix and quantity over time.

These four techniques are employed with the pull system and they lead to the true benefits of this system.

When a schedule/order is triggered with a pull system (supermarket or JIS), visual signals are immediately used to indicate the need to withdraw a fixed quantity from stock or to produce a fixed quantity. Having the minimum quantity or safety stock level to buffer any variation on the process is the first step to setting a pull system. The second step is to calculate the replenishment and/or the lead time for the product or component. Thirdly, fix the batch size that will determinate the manufacturing stock level and the manufacturing lead time, (Liker, 2003). Finally, apply the 5S principles (Sort out, Sort in order, Shine, Standardize and Sustain) to visualize all of these levels. 5S is a preventive tool of lean production that works to reduce the waste (less searching, fewer mistakes and accidents, better use of space, etc.) and as a precursor to other tools (visual inventory replenishment, standardized work, TPM (Total Preventive Maintenance), etc.).

Another element that is very important in the pull principle is the kanban. The kanban card is used as a demand signal which immediately propagates through the supply chain. Taiichi Ohno states that in order to be effective, kanban must strictly follow some rules of use:

- Process is triggered by consumption at the customer (fetch principle);
- Production only takes place if there is a kanban card in the quantity ordered and in the sequence stipulated for kanban cards;
- Delivery is made only with kanban cards;
- No defective parts or parts without a kanban card are passed on;
- The number of kanban cards may not be changed arbitrarily;
- The number of kanban cards must be regularly checked.

A simple example of the kanban system implementation might be a "three-bin system" for the supplied parts. One box on the factory shop floor, another box in the factory supermarket, and one more box at the supplier’s supermarket. The bins/boxes usually have a removable card that contains the product details and other relevant information – the kanban card. When the box on the factory shop floor is empty, the box and kanban card are returned to the factory supermarket. The factory supermarket then replaces the box on the factory shop floor with a full box, which also contains a kanban card. The factory supermarket then contacts the supplier supermarket and returns the empty box with its kanban card. Finally, the supplier delivers to the factory a full box and completes the final step of the system. Thus the process will never run out of product and could be described as a loop, providing the exact amount of inventory required. This scenario is reflected in figure 2. The kanban states how many parts should be created and by when they must be available. The secret to have a “good” kanban system depends on how many kanban cards are calculated for each product. To determine the correct number of cards and the frequency of kanban withdrawals requires some analysis. The Kanban formula is different from company to company. Most factories that use kanban have a coloured board system – *Heijunka* Box, (glossary). In a few words, the *Heijunka* box is a box with cells representing a specified duration. Each cell has a kanban card and all production orders are set into the cells, according to scheduling. Figure 3.

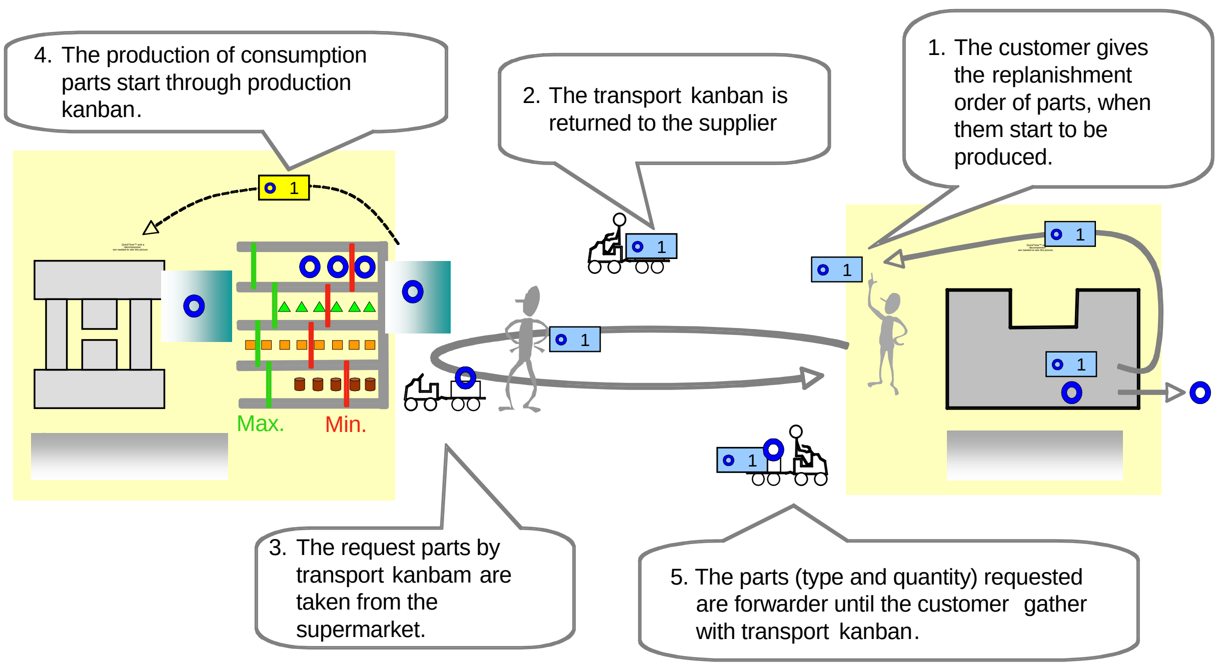


Figure 2: Kanban approach.

The kanban formula is very helpful for the supermarkets to buffer the order fluctuations. To achieve the flow described above it is necessary to have a good flow of material (like the boxes) at the appropriate times or else the loop can't run as planned. To achieve this, it's imperative to have internally a cyclical milk run (glossary) to give the material flow and externally a milk run for incoming material, both working with as high a delivery frequency as possible.

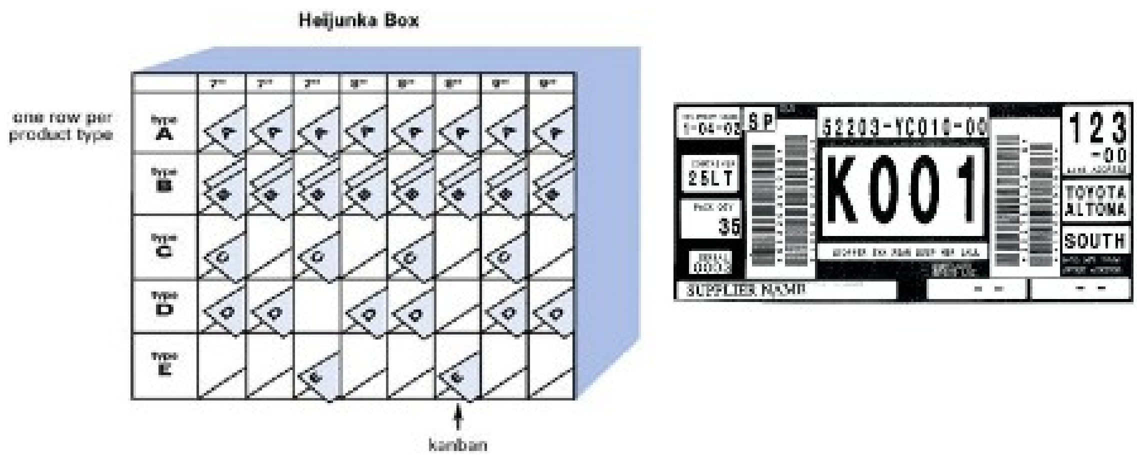


Figure 3: *Heijunka* Box and Kanban card (www.leaninstituut.nl, 2008).

Therefore, working with a pull system and extending it to the suppliers means that we are helping them to improve and also bringing to the company:

- Cost reductions – stable ramp-ups, low investments and inventory reductions.
- Quality improvements – zero defects and mastered processes with low support costs.
- Delivery services – flexibility for fluctuation of quantity and product changes, and 100% on-time delivery service.

2.3. Dealing with Suppliers

When lean production practices are implemented on the shop floor they have to be extended to suppliers. The reason is that lean manufacturing does not work well with mass production, in other words, a factory governed by pull systems doesn't achieve the maximum potential if its suppliers are producing enormous quantities for stock and sending the material not according to pull schedules. Besides, if a supplier is working with mass production standards it won't easily accomplish waste reductions and, consequently, won't have attractive figures for the company.

Toyota understood this sooner than other big companies and helped its suppliers to adopt the TPS principles (www.informit.com, 2008). One of the TPS principles is "Respect your extended network of partners and suppliers by challenging them and helping them to improve" (Womack, 1991) and this is what Toyota did. Toyota taught and still teaches their suppliers the Toyota way. However, the suppliers must prove their commitment and reach the target: high performance standards for quality, costs and delivery. So, the suppliers must learn how to work across company boundaries to achieve the best interests for both companies. The interests must be aligned with the best interests of the entire supply chain.

This concept is very important to a company once the suppliers become a part of the extended family that grows and learns with the company. It's necessary to understand this importance and to start with new suppliers cautiously. Firstly, giving to them small orders and after they prove honesty and commitment to high performance on quality levels, cost and deliveries, it seems wise to increase the orders. However, not all suppliers can improve by themselves. Supplier development program is considered a tool and technique that includes a series of great targets and challenges to help them improve and develop respect among their peers and other customers.

Supplier development programs have expanded from a quality focus to include more technologically sophisticated issues. The real goal is to have companies working together in joint cost-saving programs, cross-company brainstorming of problems, just-in-time inventory systems, concurrent engineering, and other related concepts. Eventually, more responsibility is passed to the supplier. Partnering with the supplier creates an alliance in which all key suppliers and the customer are working for the best total cost instead of the price for the supplier and customer separately. To accomplish these terms, the company should send teams to their suppliers to help them improve costs and efficiencies. On the other hand suppliers should do the same for their customers. Customers and suppliers will work together to reduce defects, downtime, cycle time, lead time, warehousing and obsolescence, etc.

One of the most important approaches is to have the suppliers work according to the company production. A pull production system forces the suppliers, especially those which have the largest volume of business or those who need help, to improve and from that obtain better results for both companies. As previously mentioned, the lean manufacturing concept doesn't match well with mass production. So, to implement lean principles on suppliers we need to go deep into suppliers' processes and understand how can they work like us. Thus, the best way to develop the supplier is to apply the Value Stream Method (mapping and design). The VSM is a Lean process-mapping method for understanding the sequence of activities and information flows used to produce a product or deliver a service. It's a charting method that uses symbols, metrics, and arrows to help visualize processes and track performance. This method helps to determine which steps add value to the process and which do not. The VSM identifies, demonstrates and decreases the waste in the process and is the starting point to help management, engineers, suppliers and customers recognize waste and identify its causes (www.valuebased management.net, 2008). It must be clearly stated that this process cannot be started in just one big step. The company needs to do a selection from all suppliers to manage the integration of this process into the supplier. To do this selection it is suggested to begin with a range selection that will cross some supplier's characteristics, like delivery frequencies, place distance, transport routes and part numbers volume. Basically, a study of supplier characteristics and conditions that will establish targets oriented toward each single supplier. Later, these targets will define clusters of suppliers. This will be very useful to carry on all processed. By using the Value Stream Method we are using a tool to graphically map and design material information flows in production and logistics systems. To do that, the main procedure occurs at the supplier's plant, starting at the loading dock and ending at the receiving dock, combined with interviews as well as identification of non-value-added activities, deviations of target concepts and lean principles. To proceed like this it's necessary to gather supplier data, such as production data, inventory levels, cycle times, delivery frequencies, stock in supply chain (in warehouse and in process), quality data, etc. Once we have a team working at the supplier's plant the very next step is mapping how the actual production and logistics system will work. Consequently, waste becomes transparent and violations of lean principles and deviations from target concepts are identified. To understand how the plant currently works is necessary:

- Follow the flow from dock to dock;
- Always go in the opposite direction of the material stream (e.g. from dispatch to incoming goods);
- Draw material and information streams with standardized symbols (VSD and lean symbols);
- Record actual process data (not standard times, but the instantaneous time!);
- For new products it helps to analyze a similar value stream;
- Drawing of the actual state forms the basis for the next step (Target State).

Therefore, after the drawing and comprehension of the current status we need to move forward with the drawing of the target state. That means drafting an improved customer-oriented value stream. Besides, for the implementation of lean principles there are seven steps to consider:

- Take customer cycle into account;
- Introduce continuous flow;
- Introduce supermarket pull systems where the continuous flow is not possible;
- Only plan one point (pacemaker process);
- Small lot production and reconciliation with pacemaker process;
- Decide whether to produce directly to dispatch or via supermarket;
- Stock issue linked to cycle in the pacemaker process.

Another element to be regarded in the pull system that isn't a manufacturing one, but fits perfectly in the pull definition is the External Milk Run (EMR). A Milk Run (MR) is a cycle method of providing materials to production at the consumption location, (Ohno, 1988):

- At the right time;

- In the right quantity and quality;
- At the right place.

The MR not only provides materials as finished goods/empties, it also, relays information between processes. Two possible ways of milk run have been defined, internal and external. The external milk run can be another challenge once can be included in the same route that several suppliers have even better results. The EMR can be delineated by company, if the latter has sufficient know-how in this issue, or by a Logistics Service Supplier (LSP). The LSP can manage supermarkets, inventories, clients and channels. In this case, the idea is to have flexibility, speed and efficiency in the deliveries from a set of suppliers with a high frequency.

Working with the philosophy of lean production we are producing only what the customer requires. Dealing with suppliers applying a pull plan, on a day-to-day basis, receiving the material "just-in-time" and just what it needs to produce is so crucial for the company. And thus, an understanding of the information flow between both sides is important too. Working with a supplier to open its horizons, helping it to catch up to the customer rhythm and implementing an order pull planning is my objective at the end of this report.

3. Case Study

3.1. Bosch Vision

Once BOSCH Termotecnologia SA embraces the case study, I would like to give it a little introduction. Bosch is a Group Bosch company with a production plant in Aveiro, Portugal. Throughout all of Group Bosch, Bosch is a part of Thermotecnology division and produces water heaters, boilers, solar collectors and absorbers. It is considered the competence center for water heating technologies and retains the development of all Group Bosch brands of water heaters for the entire world. It is the leader the European market and operates in 60 countries throughout the world, from USA to Africa and China. Bosch has a range of 1,000 to 1,200 employees, of which approximately 250 employees make up the specialist list of staff. Bosch has a production capacity of 1,500,000 water heaters and 100,000 boilers annually, having productive cells and lines dedicated to them and working in two shifts. Since some products are seasonal, in the rush period Bosch works with three shifts. The solar area has been growing since 2007 and is one of the main investment areas of Bosch. The total sales volume is nearly 200 millions of euros per year.

The suppliers are mainly Portuguese (approximately 70%), and the others parts of Europe (Spain, Italy, Germany, etc.) and Asia (primarily China).

In 2007 Bosch received the “Best Company in the Sector” award by *Exame* magazine.

Bosch is formed by a dense and varied group of departments such as R&D, Quality, Purchasing, Logistics and Production. Beyond these principal departments Bosch founded a department dedicated just to lean manufacturing, which is the basis of the Bosch Production System – BPS. Like Toyota with TPS or Ford with FPS, the lean production system was introduced in Group Bosch in 2002 and is called Bosch Production System.

The lean production in Bosch has eight principles:

- Pull System: only produce based on real customer demand.
- Process Orientation: design, control and improve procedures and holistic processes.

- Perfect Quality: avoid failures through preventive action to deliver perfect quality to the customer.
- Flexibility: flexibility regarding volumes, product variations and product generations.
- Standardization: realization of “Best in Class” standards.
- Waste Elimination and Continuous Improvement: there’s nothing that can’t be improved any further.
- Transparency: business processes and manufacturing procedures are self-explanatory. Deviations become immediately visible.
- Associate Involvement and Empowerment: clear assignment of responsibility and competence to the process level.

From 2002 to 2007 Bosch reduced the total inventory coverage from 42 days to 23 days (45% reduction); zero-mileage-defects (ppm) from 40 to 15 (62% reduction) and productivity from 6.0% to 12,5% (a 48% increase).

The company vision for 2010, in terms of BPS strategy, is to be a world-class company, for which the main strategic points are:

- Pull System from the customer to the supplier.
- Emphasis on Continuous Improvement (CI).
- Continuous associate development.
- Integrate BPS suppliers’ development.

To reach these points there are many projects associated. All of these projects are distinguished in three areas: supplier, production and customer. In other words, source, make and delivery. These are the principal areas in which we can divide the core business. Therefore, some of these projects are:

<u>Source:</u>

- Quality Improvement
- **BPS in the supplier**
- Milk Run with local suppliers
- **Pull planning with majority part of suppliers**
- **Inventory coverage reduction**

<u>Make:</u>

- Lean Line Design for all assembly lines
- Point CIP
- TPM and 5S

<u>Delivery:</u>

- Pull system – customer consumption
- Levelling of customer demands
- Stock transparency

3.2. Source strategies

Making part of source strategy projects are two points that are the triggers of pull planning with suppliers: pull planning with suppliers (BPS principle) and inventory coverage reduction. As a result, many projects were defined to implement these measures with suppliers. Bosch has been working closely with the suppliers and has currently several teams working with key suppliers. Unfortunately, not all suppliers can be selected for these kind of measures, at least until now. Firstly, Bosch is working with suppliers in which is has the most trust and those in which improvements are expected to be significant. Bosch always pays attention to the cost-quality-delivery relationship when it is doing a contract with a supplier. Due to the complexity of Bosch's final products, the suppliers are divided into material types, from copper and cardboard box as raw material suppliers, to turnery or electronic suppliers. Through this differentiation the key suppliers aren't selected by the material type, but are being taken into consideration for many other characteristics, like the part number (material) cost per piece, the volume consumed per day, and the potential damage of these parts in case of rupture. Having this selection, Bosch selected teams from key areas like Purchasing, Logistics and BPS to interact directly with suppliers and help them improve. The source strategies projects in bold on the previous page are interlinked whenever these supplier development teams are working with suppliers. The scope is detecting in the key suppliers their weaknesses according to BPS principles and showing them where they can intervene to become better. Showing that and explaining how both could work in pull scheduling, ordering in higher frequency and deliver, but in fewer quantities, will certainly have impacts on inventory reduction projects. Despite the differentiation between source projects, they are quite interconnected.

3.3. The objective

The aim of this work is to gather suppliers, analyse their characteristics and decide in which way the pull planning should be implemented as soon as possible. The challenge that I'm proposing is to apply the pull planning with the one of the largest Spanish suppliers. The supplier will be called COS supplier and the scope is the implementation of pull planning system based on daily deliveries. Besides, Bosch expects to achieve inventory coverage reduction. Adding to this, there will be given the opportunity to the supplier to know its weaknesses, to be provided with tools and/or advices to increase the productivity and value of its company.

4. Methodology

When I first introduced the theme of this thesis I intended to follow a certain timetable that I had estimated to accomplish along the journey.

On the timetable below, table 1, there's a description of all relevant steps done to implement the source project identified in the previous chapter. On figure 4 there is the schedule map overview.

Table 1: Schedule plan definition.

Nº	Date	Actions
1	01/11/2007 to 01/12/2007	Key suppliers selection
2	15/12/2007 to 15/01/2008	Pull concept presentation to supplier
3	01/01/2008 t0 15/01/2008	Team Selection
4	16/01/2008 to 31/01/2008	Data Analysis
5	04/02/2008 to 06/02/2008	Workshop with supplier
6	04/02/2008 to 06/02/2008	Problems identification
7	04/02/2008 to 06/02/2008	Definition of corrective actions and implementation plan
8	15/02/2008 to 15/03/2008	Several agreement points
9	15/02/2008	Go Live - Pull planning (daily deliveries)
10	01/03/2008	Go Live - Reusable Boxes
11	15/03/2008	Feedback meeting with supplier in Bosch plant
12	15/03/2008	Service Level measurement
13	15/03/2008 to 30/07/2008	Weekly follow up conference
14	Every month	Inventory coverage measurement
15	30/07/2008 to Current period	Continuous analysis to improve

Looking to the steps description we can figure out that there are some steps that are more important and decisive than others. For example, step 1 is the very first point and the first one that can compromise the entire plan. Supplier selection is essential, once the company has decided to start with suppliers that could bring more profit in a short term. From the range of eleven suppliers that I'm responsible for, I decided to start with one. In this case, the decision was not so complex, due to the discrepancy between the suppliers' data. From all of them, this one is the supplier that had voluminous quantities and which volume represented in stock coverage of more than 120,000 euros per month. Another decision point was the distance factor. Suppliers that have distance time greater than eight hours can't have daily deliveries. It's spatially impossible! Although this doesn't mean that we can't have daily deliveries with those suppliers.

After having the key supplier selected there was the need to introduce the pull planning concept to the supplier and organize a three-day workshop to focus on the supplier's figures. This is in fact the most important step from table 1. From the workshop outcome will emerge the supplier problems, the corrective actions and the implementation schedule that will limit the entire project. From then on, the work becomes more visible and the results begin to appear.

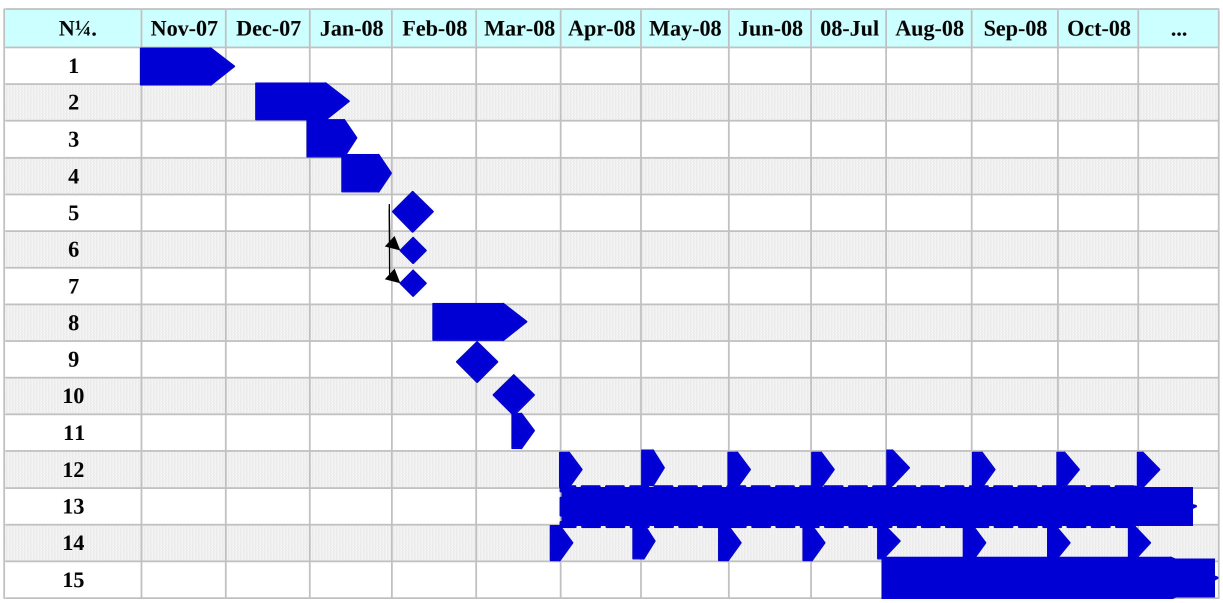


Figure 4: Schedule map

The next chapter, Discussion Results, demonstrates the major part of the table 1 steps. Once the supplier selection was done, this stage won't appear, only the supplier information. The workshop at supplier's plant is the most evidenced, because both teams will be together, building the supplier's Value Stream Mapping, discussing the problems and deciding the actions that should be implemented.

Some BPS principles were discussed with the supplier and planned to be implemented. Corrective actions, as already said were defined and those that Bosch's team mainly managed will have from now on a special headline.

5. Discussion Results

5.1. Methodology balance

Following the schedule of figure 4 in some points, especially the agreement points, took much more time than was foreseen. Some disagreement on parts price were on the list, but were handled by the purchasing department, even as one of the last agreed points.

Another delay is about the thesis theme. The main reason for that was the uncertainty will to define the central subject. Deciding a way to gather the Pull system information and at the same time all the ideas of JIT and lean principles was very difficult for me. Finally, working in Bosch's projects, specifically on the described one, I have realized that talking about pull planning with the suppliers would express the fusion between:

- A pull system extended to the whole supply chain, and
- A way to have the incoming material just when it is needed (JIT).

5.2. Results of the workshop with the supplier

Despite the real case study in one Bosch supplier, for confidential reasons some figures, details and names won't be written down. After the supplier's selection follows the workshop's main entities:

- Supplier – COS supplier
- Customer – Bosch
- Place – COS plant, Spain
- Subject – Value Stream Method workshop

Since we will work directly at the supplier's plant it is very important to draw the current state of its value stream. In this way, the following steps will guide and lead us through the supplier value stream until we understand the full COS scenario and its problems. Through Value Stream Mapping you will have the opportunity to:

• Align COS business to Bosch demands;
• Reduce COS lead times;
• Increase COS value adding time;
• Reduce cost for both companies.

5.2.1. Step One – Record Customer information

Should we start a pull system analysis with all part numbers?

The answer is no. To draw the Value Stream we need to focus on a small range of part numbers, but that range should be represented for the whole supply chain. These parts should cross as many processes as possible to give us the maximum information as possible and should have an important weight in supplier production. COS supplier has more than 180 active part numbers, and the part number choice was based on the quantity average ordered from Bosch to COS, number of processes that the part number enters, and the determination of *Takt* Time. The first selection was made and three part numbers were chosen. From that range should be elected only a part to be used on the VSM.

First part selection:

- 8-703-404-212
- 8-708-502-036
- 8-700-305-178

Thus, with these parts we needed to settle the volume, delivery frequency, quality data and all the information that we can get – table 2.

Table 2: Supplier and customer information.

Par Number	Designation	Yearly Demand (Units)	Delivery Frequency	Transport Agreement	Information Flow (Bosch-COS)	Information Flow (COS-Sub-supplier)	Quality Target (PPM)
8-703-404-212	Screw	888.100	Weekly	Ex-works cross-dock	1 weekly order + 6 weeks forecast + 6 months forecast	2 weekly order + 1 year forecast	0
8-70-501-036	Command cone	432.000	Weekly	Ex-works cross-dock	1 weekly order + 6 weeks forecast + 6 months forecast	2 weekly order + 1 year forecast	0
8-700-305-178	Cap	12.000	Weekly	Ex-works cross-dock	1 weekly order + 6 weeks forecast + 6 months forecast	2 weekly order + 1 year forecast	0

With this information we have the potential part number for the VSM. Finally, to choose one it will be necessary to calculate the *Takt Time*.

5.2.2. Steps Two and Tree – Plant tour to identify and map the main processes and Draw material flow

The idea is to go backward from the customer order (Bosch) process until the sub-supplier raw material delivery, and record clearly the identification of processes. All the material flow and the existence of inventory between processes, eventual scrap, working machines, operators per shift and all that we can consider relevant for the actual status should also be identified. Before we put down the draw structure, the first point to start the calculation of ***Takt Time*** (TT) for the above part number selection. The TT is used to synchronize supplier and customer rhythm and describes the frequency demand from the customer. The formula is described in figure 5.

$$\text{Customer } \textit{Takt Time} = \frac{\text{Working secs per year}}{\text{Demand per year}}$$

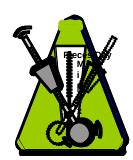


Figure 5: *Takt Time* formula compared to tachometer.

$$TT(\#212) = \frac{208x16x3600}{888,100} = 13.5 \text{ secs/pc}$$

TT(#036) = 27.7 secs/pc

TT(#178) = 107.6 secs/pc

The working seconds per year were determined considering two shifts per day with eight hours each covering 208 days. Having the value for the previous three part numbers we can choose the part number that will be used on the VSM. The chosen part number will be the one with lowest *Takt* Time value, since it represents the shortest order frequency that COS needs to deliver the material to its customer (Bosch). After that, it's necessary to walk in the field, checking the stream processes and describing them just like a picture. On figure 7 it's possible to see the first draft of the VSM from COS. At the same time that we are doing this analysis we can move to the drawing of the material flow (structure) – step three. At this step we are complementing the scenario at the customer's plant. We identified several processes at production (step 2) and now we need to link them. These process links can be push, pull, FIFO, etc. As we can see in figure 6 the material flow between the processes is already defined. The processes are almost in push flow (⇨) and only one, the order preparation step, is in pull flow (⟶). In another sense, just as Bosch makes the order, COS acts in a way to prepare the material. All manufacturing processes are made without having taken those orders into account.

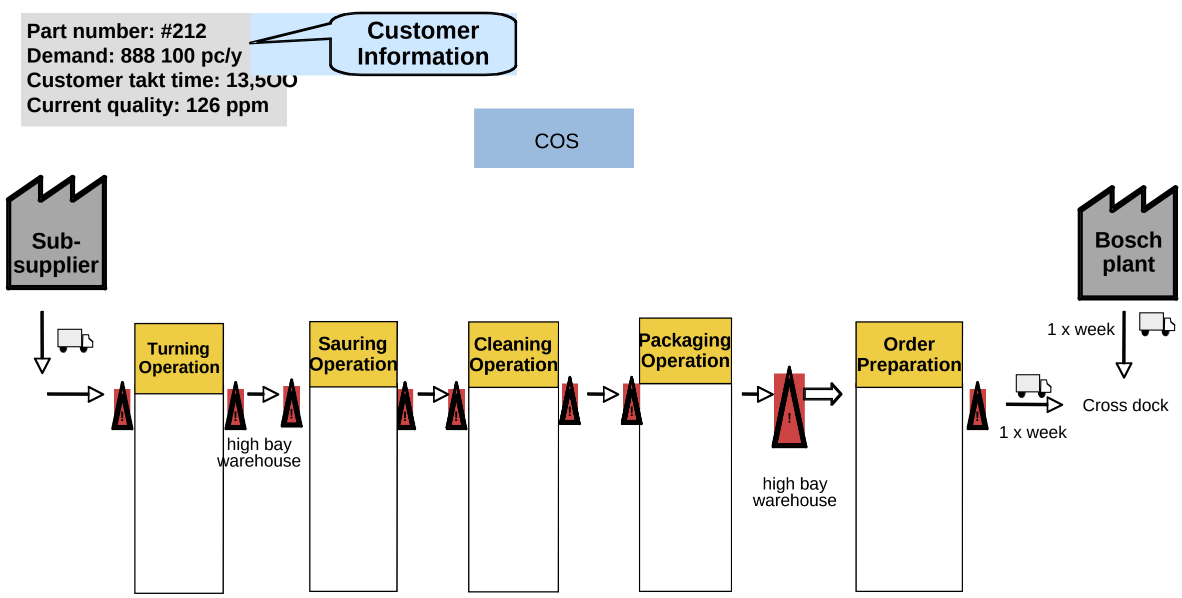


Figure 6: VSM – Steps 2 & 3

5.2.3. Steps Four and Five – Determine and fill in data and key figures regarding the material flow and plant tour to identify and map the main process

To add this step we need to calculate some data for each process (cycle time, process time, set-up time, lot size, stocks, Work-In-Process (WIP) stock, Overall Equipment Effectiveness (OEE), working hours/shift models, scraps/rework, Change Over Time (COT). Following is some of the most important:

Cycle Time – time in seconds that elapses between one part coming off the process to the next.

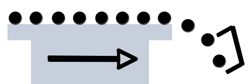


Figure 7: Cycle Time (CT)

Process Time – time in seconds that a work piece runs through a complete process.

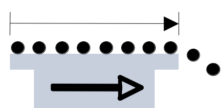


Figure 8: Process Time

$$\text{OEE – Overall Equipment Effectiveness} = \frac{\text{Net production Time}}{\text{Planned operating time}} * 100$$

Or

$$\text{OEE} = \frac{\text{Number of good parts * technical cycle time}}{\text{Total available time – planned downtime – planned maintenance}} * 100$$

COT – Change Over Time – time between when a last good piece comes off of a machine or process and the first good piece of the next product is made.

Set-up Time - total time required to change settings and tooling from one production run to another. Minimizing set-up time is a key factor in reducing lot sizes and thus lead times.

Lot Size – quantity defined to produce items to order or to stock.

WIP - material that has been partially processed but not yet transformed into its final state and not normally usable as is.

With the calculus above we can fulfill the data field of Process Box – step 5 and complete more data on VSM, figure 9. Some values, like, COT or OEE were provided by COS production department.

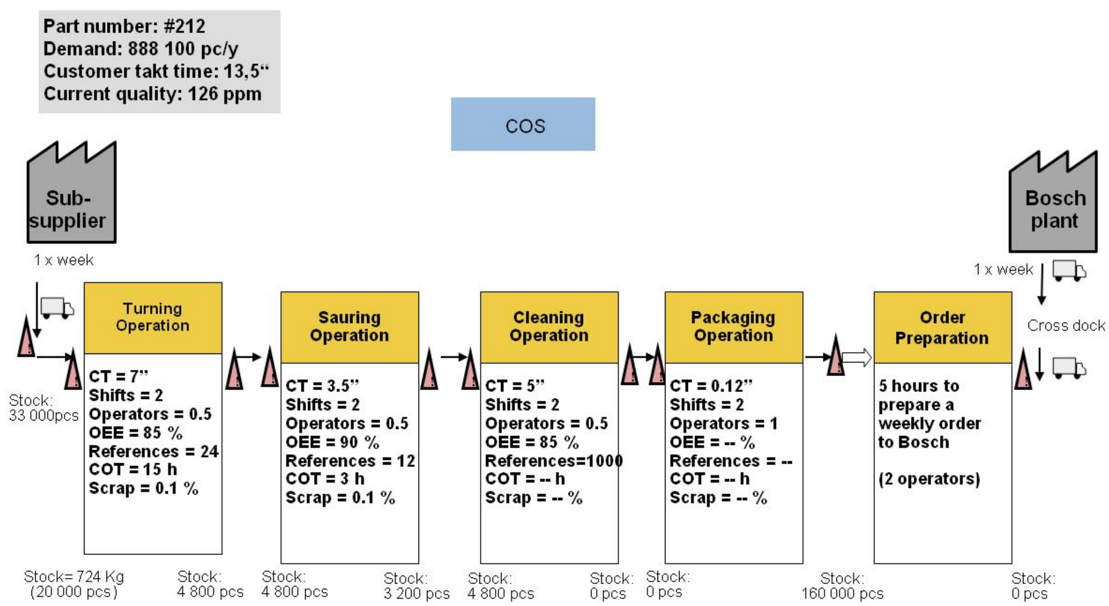


Figure 9: VSM with process boxes fulfilled.

With this step completed we can start looking at the value stream with a global vision. We can find all the stock, since warehouse to stock in process, between the processes. The cycle times of each process and number of parts or operators per process is also identified.

5.2.4. Step Six – Calculate the throughput times and value information flow

The Throughput Time, figure 10, is the time to run a work piece all the way through the value stream. In theory it can be considered as the rate at which a system generates money.

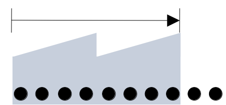


Figure 10: Throughput Time

To have a calculated example, the throughput time for the starting point at a sub-supplier is:

Throughput Time = TT x QTstock = 13.5secs/pcs x 33,000 pcs = 445,500 secs

$$= \frac{445{,}500\text{sec}}{16 \text{ h} \times 3600 \text{ secs}} = 7.7 \text{ days}$$

So, 7.7 days is needed to convert the stock into "money", i.e., into final product ready to be sold. The sum of throughput time will give us the production lead time for the part number in our analysis. Basically, it will be the time that it takes the part number for move all the way through a process or value stream. The sum of all process times will demonstrate the value added time. This is the time that actually adds value to the part number's journey. As we can see in figure 11, under each process is the lead time for that process (throughput time) and the associated process time.

Analyzing the VSM of figure 11 we can see that the supplier has 54 days to produce a complete piece of part number #212. Although it only needs 15.68 seconds to produce a entire piece of part number #212, everything else is waste!

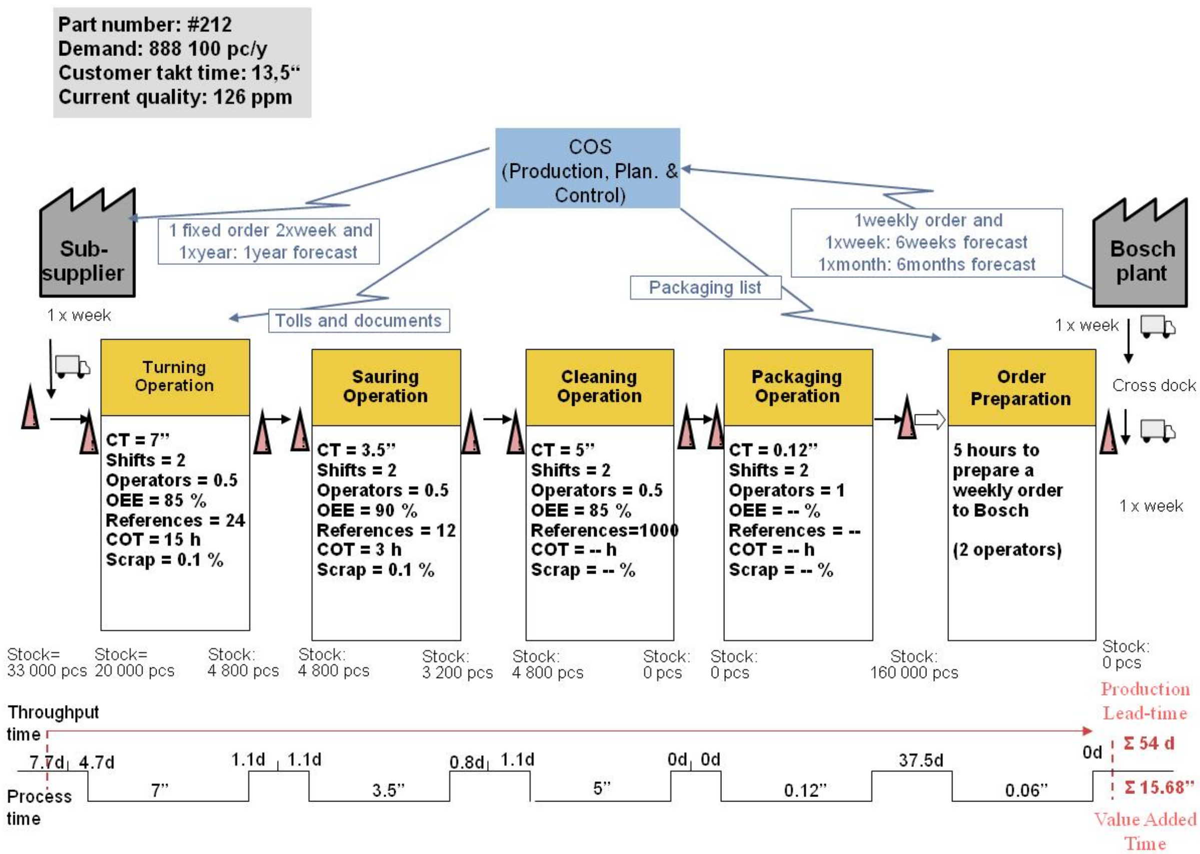


Figure 11: VSM with the Throughput and process time defined

5.2.5. Step Seven – Calculate highlight and describe violation of lean principles and deviations from target concepts.

At this step we will assess the VSM with the purpose of finding all the violations that we detected on throughout the value stream and then for each we will try to find the idea or action for future improvements. So, first, we identify the problems and then we trace the improving actions and create an implementation plan for them. In the future, these actions could also be measured and new improvement actions can replace them.

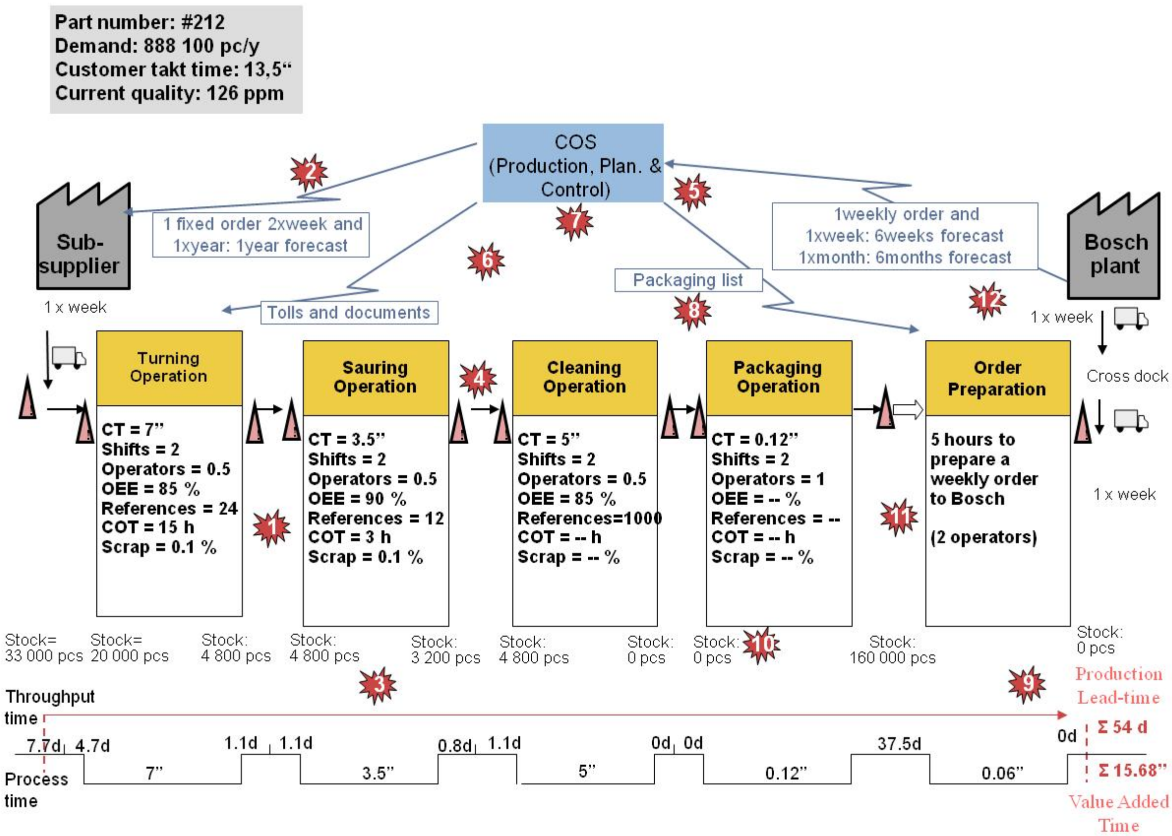


Figure 12: VSM identifying the lean violations

We call these red flashes Kaizen-Flashes and in COS value stream mapping we detected twelve of them. For each problem identified the correspondent corrective action was determined and, in the end, it was decided to implement them. In the table 3 it’s possible to see the twelve main problems that are contrary to BPS principles and the correspondent corrective actions. All of these points were properly discussed amongst the entire team. And using Bosch knowledge from previous experiences and COS experience in its manufacturing processes, the corrective actions were settled in common agreement.

Table 3: 12 violations and the corresponding corrective actions

	Problems	**Actions**
1	Long change over time (COT = 15h)	Stabilize and decrease the COT
2	Minimum orders with sub supplier	Increase the orders per week with sub-supplier
3	**Large batch size**	**Reduce the minimum batch size**
4	Push System	Pull System
5	**Production planning based on forecast**	**Production plan based on customer consumption (supermarkets dimensioning)**
6	Waste (movements in cleaning area)	5S implementation
7	Communication strategy	Implementation of one communications corner (customers; quality complains; overall efficiency)
8	Low packaging operation	Improve dispatch process
9	High coverage (54 days)	Reduce the intermediates stock
10	Hight set-up	Economical study for set-up time reduction
11	**Transportation MUDAS**	**Change to standard boxes**
12	**Low delivery frequency**	**Start with daily deliveries**

As a customer, Bosch will mainly intervene in those actions that are essentially depending on it. Shown it bold on table 3 there are the actions that Bosch will lead and thus will be those that I will focus on.

How can we treat the selected actions? What is the plan?

The first step is deciding an implementation plan with time limits. This plan will help us to follow the actions, checking the status and controlling them. Below, in table 4, there’s the implementation plan, defined in months. Once again, this implementation plan has only the actions that Bosch team has responsibilities for (partial or total). The other actions will be done by the COS team and for that reason will not be identified here as results.

Table 4: Implementation Plan

Nº.	Implementation Action	Responsible	Time Schedeule						
			M0	M1	M2	M3	M4	M5	M6
1	Agreement of new minimum batch size of parts numbers	LOG/Bosch & LOG/COS	■	■					
2	Change SAP parameters	LOG/Bosch	■						
3	Define box type and quantities per box	LOG/Bosch	■						
4	Standard boxes	LOG/Bosch		■					
5	Start with daily deliveries: Milk-Run	LOG/Bosch & LOG/COS	■	■					
6	Measurement of service level	LOG/Bosch		■	■	■	■	■	■
7	Follow-Up Meeting	Team		■		■		■	

The M0 is the first month (February) of implementations and was considered to be the same month as the VSM workshop. The target is having all the action implemented sixth months after the project initiation. The workshop took place in February 4th to 6th and the results should begin to appear until the end of first semester, to have quite significant improvements until the end of current year.

Despite the implementation action steps, the numbers of table 4 don't correspond to the number of problems/actions of table 3, rather they are sorted by the same order, following the same sequence.

5.3. Running the implementation actions

After the workshop to assure the evolution and completion of corrective actions, very useful follow-up meetings were held. Looking to the table 4, the point that stands out immediately is the transition from weekly deliveries to daily deliveries. In fact, this is the highlight and the greatest point from the implementation actions.

Starting with the implementation action number 1 is necessary to revise and redefine the minimum batch size for COS part numbers.

Which kind of parts numbers should be in a Pull system plan?

At the beginning and once the supplier will be in the ramp-up phase, a percentage of errors can be expected to occur. To avoid critical issues, some preventive actions can be done. A part number selection could be a good preventive action until we completely trust in the supplier's new system. This selection can be done based on parts with regular consumption (weekly basis). This means parts don't suffer big fluctuations week by week and the daily orders will be quite regular. So, if a range of a part number has insignificant variations among the weeks, approximately 20% to 30% of variation, they will fit perfectly in the pull system with the supplier in the ramp-up phase. Over time, we can always the number the number of parts on the pull list. That is just a question of SAP parameters definition.

Thus, Bosch selects these part numbers based on historical consumption and six weeks forecast. This list has in fact almost all of the parts that we order from COS. Part of this selection can be seen in the appendix. There is a table with some parts and the respective consumption pattern. Only a small amount will be ordered under the old conditions, i.e., weekly. Nevertheless, the improvement will be general.

The next step will be the definition of a minimum quantity per batch size. This is a very important step because this quantity definition will be the minimum quantity that Bosch will order and consequently it will restrict the order to those quantities even when the needed quantity is less. We can start to propose these quantities or wait for the COS proposal. Bosch received from COS a list with all parts that were selected for "pull" – daily deliveries, and was analysing for each one if those quantities were reasonable or not for our needs.

How can we do it? To answer this question I will need to bring up one subject that is the pacemaker of consumption replenishment that will define what we will order from the supplier. This subject is the Maximum Stock Level definition. And what is that MSL?

MSL = (Total Lead Time + Safety Stock) * Daily consumption

Total Lead Time = $LT_{plan\_freq.}$ + $LT_{sup.}$ + $LT_{transp.}$ + $LT_{recep.}$ + $LT_{control}$

Daily consumption = Higher value from C_{week} or C_{week+1} / Nº workdays

$LT_{plan\_freq.}$: planning frequency;

$LT_{sup.}$: supplier process;

$LT_{transp.}$: transport;

$LT_{recep.}$: reception;

$LT_{control}$: quality control.

The MSL is a formula that reflects the stock quantity that Bosch should order for a part number. That quantity is calculated according to the total lead time of a process (from the supplier to the customer) plus safety stock (if necessary), multiplied by the daily consumption. Looking at this in a practical way I'll use the part number #212 the VSM example.

Table 5: Part number daily consumption and several lead-times.

Part Nr.	Daily Consum. (Units)	Safety stock (days)	LT plan. frequency	LT supplier process	LT transport	LT reception	LT quality control
8-703-404-212	2823	1	1	2	1	1	0

The daily consumption is an average of the weekly consumption. In the table 5 we can see the current week consumption (Week 0) and the following week consumption (Week 1).

Considering the highest consumption from both weeks and dividing those quantities by five working days, we will find the daily consumption.

Table 6: Part numbers consumption of two weeks.

Part Nr.	Designation	Week 0 (units)	Week 1 (units)	Daily Consuption
8-703-404-212	Screw	14115	12876	2823

Why do we pick the highest week consumption? We should choose that amount because if we will consider the lower one we could encounter stock rupture, especially if we have a consumption peak day.

Having this explained we can finally define the MSL value for these part numbers:

MSL #212 = (1+1+2+1+1+0) x 2823 = 16 938 units

So, where will the Maximum Stock Level be used? The MSL will be used as a parameter in the SAP system to automatically generate the daily orders to COS. Setting the SAP parameters is one of the actions that must be done for the introduction of daily orders and daily deliveries based on consumption (pull). Each part number created and allocated to one contract (supplier contract) has a master datasheet that defines the part number characteristics, like an ID. That master data is accessible through a SAP transaction called Material Master. There we can introduce and define some part number characteristics. One is the MRP (Material Requirements Planning) type where we can define if the part is in pull or not. Therefore, the list of part numbers that we want to integrate as pull (based on real consumption) will be defined in that way on the Material Master. Doing this requires that we introduce the value of MSL into the SAP system. This value will be the part number stock quantity target. Every time that the stock quantity of one part is under this value an order will be triggered.

Table 7 demonstrates how pull planning works. We have the working days, the stock at the warehouse on the first day, and all the needs for this week. I would like to point out that this scenario cannot be considered as static, but dynamic. Lets approach it with just two days of fixed needs. For example, on Monday I know that my real need is 2,800 units and for the following two days, Tuesday is 2,600 and Wednesday 2,900. Only on Tuesday will we know for sure that the quantity needed for Thursday will be 3,000 units, and so on. We have three weeks represented and the MSL is automatically recalculated each week, being adjusted to the current needs. This is a settled point since there are weekly fluctuations.

Table 7: Pull planning scenario

		A	B	C	D	E
		8-703-404-21	Warehouse Stock	16938		
		Weekday	Needs	Stock	Order	MSL
1	W1	Mon	2800	14138	0	16938
2		Tue	2600	11538	2800	
3		Wed	2900	8638	2600	
4		Thu	3000	5638	2900	
5		Fri	2815	5623	3000	
6	W2	Mon	2700	5538	3097	17220
7		Tue	2950	5488	2685	
8		Wed	2900	5588	2950	
9		Thu	3000	5685	2900	
10		Fri	2800	5570	3000	
11	W3	Mon	3000	5520	2800	17520
12		Tue	2750	5670	3300	
13		Wed	2900	5770	2750	
14		Thu	3000	5570	2900	
15		Fri	2950	5920	3000	

Thus, assuming that we have the MSL quantity of 16,938 units for the Week 1 and in rows 1 through 15 we have the daily consumption, how will the pull plan flow? Firstly, what the SAP system will do is to check every day if the warehouse stock is under the MSL quantity. Analyzing again the example of table 7, on Monday (row 1) we start with 16,938 units in stock and during the day we consume 2,800 units of part #212. So, in the first day no order will be triggered since the stock is equal to the MSL. However, in the following day, Tuesday, the stock is 14,138 units because we used 2,800 units of day before. The SAP system will compare both values again (MSL and potential stock) and because the quantities are different, an order will be triggered. This order will be the difference between MSL and the potential stock that is exactly the quantity of the day before consumption. On the third day, Wednesday, we will have the same situation, having only the information that the potential stock will be the supermarket stock plus the transit stock (previous day's order of 2,800 units). On Thursday, the reasoning is the same and finally on Friday, the first order of 2,800 units will arrive at the warehouse. The MSL and potential stock are again compared and a new order will be triggered once again. On Monday of Week 2, the MSL is adjusted and the order planning will take that into account. As we can see on rows 6 and 12, the order won't be exactly the previous day before. This is a result of the MSL change. Following the warehouse stock we will figure out that they suffer a tendency to a stock level and this level is almost close to 5,500 units at Bosch's warehouse.

However, this scenario has a "but". The reasoning above has been considering unit orders and not orders based on batch size quantities. And it's now that the definition of batch size should enter and the implementation action number 1.1 (agreement of the minimum lot size) is settled.

Table 8: Minimum batch size proposals

Part Nr.	Daily Consum. (Units)	Batch size (COS proposal)	Batch size (Bosch proposal)
8-703-404-212	2.823	1.000	500

Fortunately, after a discussion of which batch size proposals both companies should accept, it was decided to consider the major part of batch size proposed by Bosch. There was a small percentage (8%) of part numbers whose batch size was kept equal to the COS proposal. So, if we take a step back to the consumption scenario of part #212 in table 7, the quantity ordered should be a multiple of the batch as demonstrated in table 9.

Table 9: New pull planning scenario respecting the batch size

		A	B	C	D	E
		8-703-404-21	Warehouse Stock	16938		
		Weekday	Needs	Stock	Order	MSL
1		Mon	2800	14138	0	
2		Tue	2600	11538	3000	
3	W1	Wed	2900	8638	2500	16938
4		Thu	3000	5638	3000	
5		Fri	2815	5823	3000	
6		Mon	2700	5438	2500	
7		Tue	2950	5488	3000	
8	W3	Wed	2900	5588	3000	17220
9		Thu	3000	5088	3000	
10		Fri	2800	5288	3000	
...	...	...	...	...	...	...

Once again it's explicit that there is a trend in the stock. The stock remains in a range level that permits stock reduction coverage. The MSL is dynamic and responds to rise and fall of consumption needs. And that's why it's such a powerful tool.

The next step is the implementation of action number 3 that considers the reusable boxes (standard boxes from Bosch). There are different types of reusable boxes, but for transportation purposes and pallet dimensions the KP type (30x40x12 cm) was selected, figure 13.

Figure 13: KP Box

To define the quantity per box it is essential to know how many bags (1bag = 1 batch size) could fit into the KP box without exceeding the limit of 15 kilograms. This weight restriction is due to handling reasons, since it is very hard for an operator to manage the handling movements above this weight. A list with maximum quantity of units per box was sent to the COS supplier and was accepted. A KP box could have only one bag with batch size or in maximum it could have more than that, but always staying below the weight limit. In table 10 we have the maximum quantity per box. Thus, at the most one KP box could bring two bags of the batch size (500 units). For example, if the Bosch order is 500 units of part #212, COS just needs to send one bag in KP box. However, if Bosch orders 3,000 units, COS should send three KP boxes with 1,000 units inside each one.

Table 10: Definition of minimum quantity per KP box

Part Nr.	Batch size	Maximum quantity per KP box
8-703-404-212	500	1.000

Having defined the maximum quantity per KP box, it is necessary to define the total number of boxes needed for the rotation flow. To calculate the daily coverage of boxes the same reasoning is followed. Next there's the calculation of the lead time and the average quantity used per day.

Total Lead Time = $LT_{plan\_freq.} + LT_{sup.} + LT_{transp.} + LT_{recep.} + LT_{control}$

However, the $LT_{plan\_freq.}$, $LT_{recep.}$ and $LT_{control}$ should be equal to zero days. So, the Total LT = 0 + 2 + 4 + 0 = 6 days. For safety stock we will consider an extra 3 days. To box coverage we will need 9 days. The determination of total coverage will be based on the daily consumption. For example, the daily consumption of part #212 is 2,833 units. Considering the batch size, the quantity will be 3,000 units per day. Thus, the coverage will be:

Coverage #212 = 9 days x 3 box/day = 18 boxes available for this reference.

Total parts coverage = Σ Coverage of each part number

To have these boxes available there are costs involved. This kind of box can be expensive, but on the other hand, Bosch could reduce the price of part numbers if COS doesn't have the packing costs. This point was one of the ones took more time to get an agreement between the COS and Bosch purchasing departments. Another benefit is the fact that with KP boxes, the material won't need to be re-packed. Receiving the parts like this, the warehouse doesn't have the extra work of transferring the material from the supplier's packaging into Bosch standard boxes (including KP boxes) and will save handling time. The material also flows directly to the production floor in these boxes creating a normalized supply.

Finally, with those steps defined (batch size, SAP parameters, maximum quantity per box and tools to implement them) it's possible to plan daily transport definitions. Until now, we have assumed working on a daily basis with COS, but without having this flow yet defined.

When daily transport is mentioned, we can easily think that daily transport will mean a cost increase. And up to a certain point that's true, increasing from a weekly delivery to a daily delivery will increase the transportation costs. Therefore, how can Bosch use that daily transportation flow as a profitable point? The answer is to combine more suppliers together with daily deliveries. It must be clear that, when Bosch thought in this approach with COS supplier, other local Spanish suppliers were in the same position and this kind of analysis was made with them too. As already mentioned previously, Bosch has more teams working with other key suppliers. Thus, having daily deliveries, which at the beginning could seem to require an extra cost, is in fact, seen as the best way to reduce costs, especially the inventory coverage cost. Big inventory coverage is one of the principal wastes that many companies have and is not very simple to eliminate. Having as many suppliers as possible working in pull systems, delivering the proper quantities in the minimum time, contributes considerably to the reduction of inventory coverage. The reduction of inventory coverage is one of the main targets for Bosch and is measured every month as a key indicator.

To have a daily transportation, which Bosch calls the External Milk Run, it's necessary to define routes. To do that, Bosch opted to contract a trustful forwarder that has been working with Bosch as the responsible for the daily deliveries to Bosch. In Spain, in the Basque Country, there's a cross-dock at Vitoria town, where every day a truck passes in a number of Basque suppliers loading the material ordered on the day before and every day from cross-dock to Aveiro a truck leaves with that material. The route works in both directions since it has to transport the reusable boxes (Aveiro-Vitoria) and the incoming material (Vitoria-Aveiro). It is important to say that the material and transport responsible for Bosch is in charge only from the cross-dock. Even though the forwarder is the same, the path between the cross-dock and the supplier and vice-versa is from the supplier's charge. So, Bosch calls this daily route transportation the Spain External Milk-Run, since the distance is less than eight hours. Besides this Milk-Run route, Bosch has four other implemented daily routes in Portugal. In all of them, the suppliers are working at the same level, figure 14.

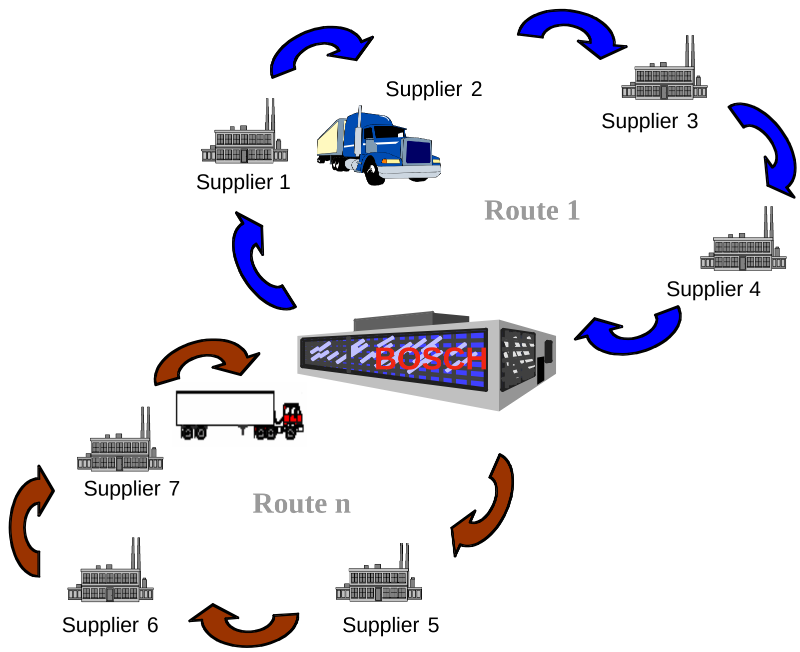


Figure 14: External Milk Run

With daily deliveries Bosch started to measure the service level that COS provides. The idea is to have a deliveries accomplishment control and an assessment tool to measure it. Every week the material planner uses an SAP transaction that allows him to calculate the accomplishment of the daily schedule. This tool is a great help to analyze if the supplier is doing a good job to reach the project target.

Doing a consolidation of the previous implemented points, the pull planning flow represented in figure 15 shows the interaction between the key value stream elements. The scenario includes the pull daily plan to suppliers as SAP orders, the main target of the source project, and shows how the information flows around Bosch's value stream.

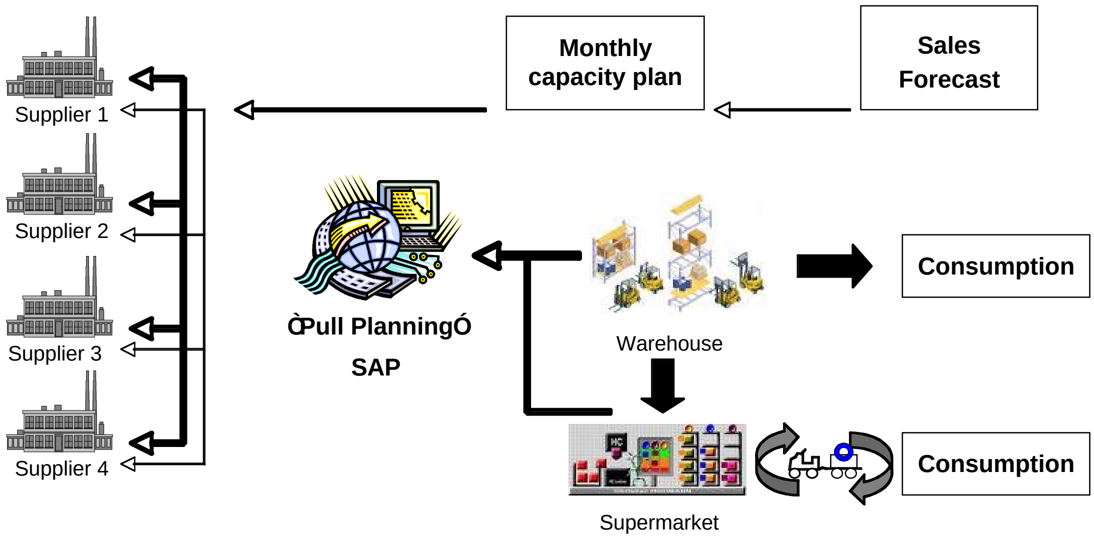


Figure 15: Pull Planning Flow

Explaining figure 15 we have the suppliers in Pull Planning receive every month, a six months forecast based on sales forecast and with the SAP system the plans are sent every day as a response to the previous day's consumption. The suppliers that are still working on a weekly or monthly basis will have order made according to weekly or monthly consumption.

5.4. Final Results

To review the pull activities in a supply chain is necessary to help the supplier figure out its deficiencies and enable it to adopt a pull system and BPS principles. This means that the implementation of a pull system with suppliers can guarantee the material availability always as necessary, not only without increasing inventory, but actually decreasing it.

5.4.1. In Customer - Bosch

Mentioning an economical study, with the introduction of pull planning with COS supplier, Bosch has the following savings and costs:

Savings:

- Supplier costs per piece;
- Supermarket handling;
- Inventory stock.

Costs:

- Reusable boxes;
- Daily transport.

To provide a general idea of the values involved, an analysis follows in table 11 and figure 16:

Table 11: Bosch's economical study.

Item	Value (€)
Empties return truck meter cost	150
Cost per returned pallet	45
Yearly cost for returns	**9900**
Cost of boxes (3 years inv.)	**1000**
Savings FTE	**3125**
Stock savings	**35000**
Yearly parts price savings	**100000**
Profit	3025

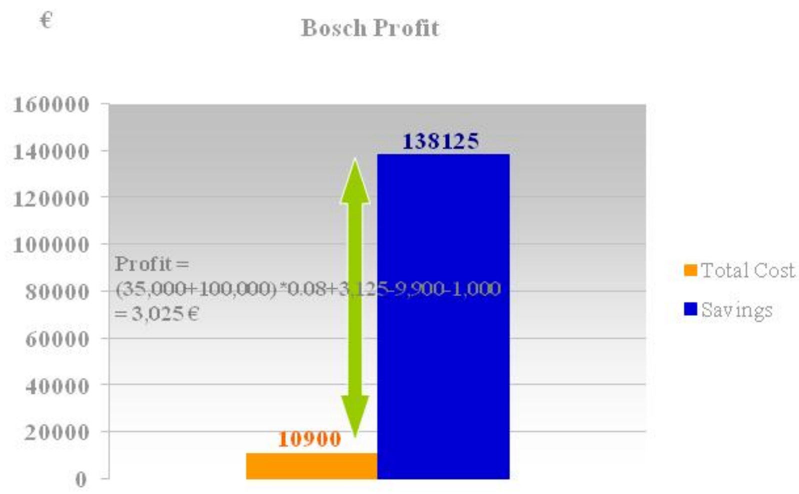


Figure 16: Bosch Profit

In fact, Bosch has spent 10,900 euros to have the reusable boxes implemented. The main cost is the returning of these boxes to the supplier. However, the price reduction per part due to stock reduction is enough for Bosch to realize a payback on its investment in one year. The profit formula in figure 16, considers the rate of 0,08 to convert the saved money as money available to invest.

Another figure that is interesting to be reported is the stock evolution of COS material since the beginning of this project.

Looking to figure 17, we can see that from the beginning of daily deliveries in March, and with a pull planning considering the maximum stock level to order, the stock has been decreasing since then. At the beginning the stock level was about 120,000 euros and now it is in less than 50,000 euros.

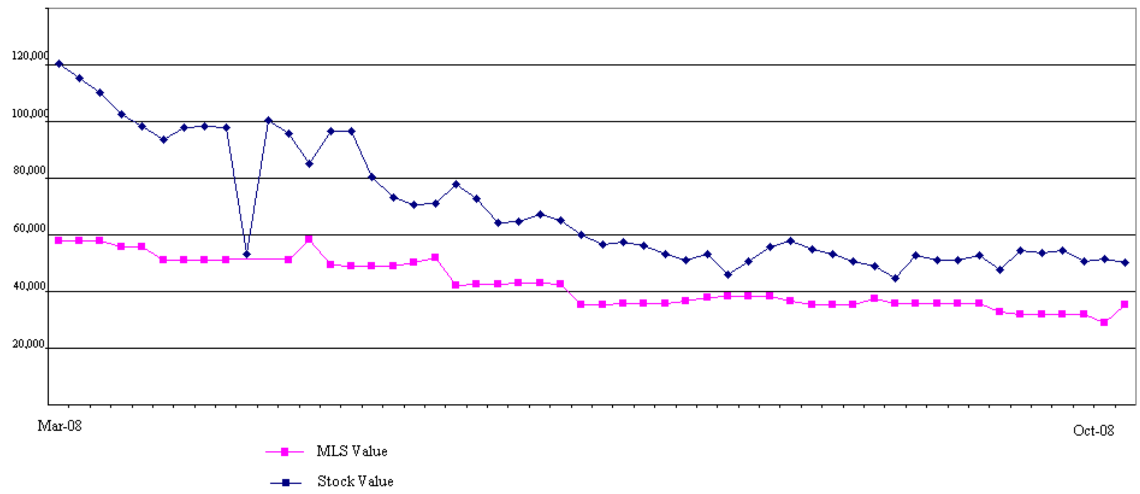


Figure 17: MSL and Stock value of COS part numbers

However, I can consider that the main targets were accomplished. Following-up this evolution and the results at the supplier, it's possible to improve the results even more and to start new projects.

5.4.2. In Supplier - COS

The supplier COS gained visibility to its problems in their supply chain and understood what is possible to do to be a more competitive supplier. The Value Stream Mapping process served as a leverage to trigger a series of continuous improvements inside their business. Sometimes some outside help is needed to clear the ideas and decide on the right actions to bring improvements and consequently greater profit. Bosch helped COS to understand that and to determine the best way for it to design the future value stream. Kaizen (glossary) experts held that the problems defined during the VSM and together with COS are integrating a pull system in COS production floor. Another important issue that lets the supplier buffer the customer's fluctuating orders is the establishment of supermarkets. The supermarket's existence guarantees the availability of material that is needed to accomplish the customer's demand. And this element of the process works also according to the replenishment levels, which will be determined in function of several delivery terms involved in the supply process.

Unfortunately the results that COS obtained weren't as good as the Bosch results, as COS is still applying the same pull planning strategy in their suppliers and is still working on the pull system implementation of pull and levelling. COS knows how far it has to go to implement lean principles, confirm them, and act with them. Even though COS is growing as a Bosch supplier, increasing the range of part numbers helps to build trust and establish a long-lasting partnership.

6. Conclusion

6.1. The expectations

When I started to do this thesis I had in mind some expectations that I was hoping to accomplish. One of them was related to my personal enrichment, extending to scientific development and research, whose scope was to add value to my career boundaries. Now, after almost a year of work, I can assertively say that a lot of subjects that at first were a little confused are now understood.

The second expectation is perfectly connected to the subject of this paper: to discover the direct main benefits of having pull planning with suppliers. During the daily work with COS I've realized that the improvements were significant and COS is increasing the performance month by month. Right now, COS has approximately a 97% service level rating and the inventory target for this year is close to being accomplished.

Along the way that I was reading, writing and understanding the lean principles, tools and supply chain, I arrived to some general conclusions how one is always working always towards continuous improvement, waste elimination and particularly employee satisfaction. Working in a lean environment like this, we absolutely can show a better performance and do not waste time with the same issues that can be solved first. These days, efficiency means cost reduction. In fact, by applying the lean principles we are reducing waste and therefore costs. A pull system working throughout the supply chain contributes for this assumption. And when we look directly to the pull planning with a supplier, as the case study, the most remarkable points are:

- Reduction of delivery time (JIT concept);
- Reduction of stocks (inventory coverage)
- Increase of flexibility due to the batch size reduction;
- Transport optimization (load and frequency).

During my research many books, Internet sites and articles were read and sometimes, I must confess, I was quite lost with of the varied information. Sorting that information out was definitely the hardest part of the job. At some moments I was trending toward extending the subject instead of narrowing it. Facing this problem, the connection between the lean philosophy to pull planning with suppliers was easiest and the case study was crucial to show that. The fact that I'm working in Bosch helps in a significant way for me to comprehend and experience the main theme. It is also imperative to say that it was my decision to specify from all actions what could be done at the COS supplier plant, those that seemed to be more interesting and enlightening for my thesis subject.

6.2. Main Conclusions

I can conclude from my work that applying the pull system throughout the entire supply chain (Total Pull) is the only way to gain the maximum potential of pull system advantages:

- Inventory reduction;
- Time reduction on doing delivery plans (SAP automatic plan);
- Reduction of transport types (transport standardization);
- Material rotation;
- Less dependence on software control;
- Processes orientation and standard processes with suppliers (more than one process with suppliers will increase the waste);
- Transparent material and information flow between supplier and customer;
- Flexibility on ordered quantities;
- Time reduction on handling of material;
- Supplier competitive material price;
- Higher customer and supplier service level.

The pull planning must be extended to all of the company as much as possible. Even the suppliers that do not have the same conditions as COS, for example suppliers with very long lead times, can be integrated into pull planning. Even if it means going forward step-by-step, supplier after supplier. We can always have long lead times with suppliers due to geographical distances, but we can always decrease that lead time and delivery frequency as JIT concept, if we adopt new systems, like for instance consignment stock.

Therefore, the implementation of pull plans with suppliers is just a step in the continuous journey of today’s industry, but without it some other essential principles and methods couldn’t produce the desired effect.

Even the pull planning can be improved! There are other ways and more advanced ways of pull planning: more than one delivery per day, vendor management inventory (VMI), ship-to-line, etc. Concluding, we can always improve!

The next steps with COS will be the reduction of total lead time to 5 days and the reduction of some batch sizes.

References

Books

CHOPRA, Sunil and MEINDL, Peter; Supply Chaon Management, Strategy, Planning and Operation; Prentice Hall; 2001;

COOPER, Martha C. and Lisa; M. Ellran; Characteristics of Supply Chain Management and Implication for Purchasing and Logistics Strategy; The international journal of Logistics Management, Vol. 4; 1993;

JONES, Daniel, WOMACK, James; Lean Thinking: Banish Waste and Create Wealth in Your Company, Simon & Schuster Ltd, 2003.

LIKER, Jeffrey K.; The Toyota Way – 14 Management Principles from the World's Greatest Manufacturer, McGraw-Hill; 2003;

MAGEE, David; How Toyota Became #1: Leadership Lessons from the World's Greatest Car Company, Portofolio, 2008;

OHNO, Taiichi; Toyota Production System: Beyonf Large-scale Production, Taylor & Francis Inc, 1988;

WOMACK, P., JONES, James, T., Daniel, ROOS, Daniel; The Machine That Changed the World: The Story of Lean Production, HarperCollins Publishers Inc, 1991;

The Burton Group (2001), "The benefits of Lean manufacturing";

Talach, Chad; Integrated Lean Logistics; Transfreight Lean Logistics;

Internet sites

http://www.sme.org/cgi-bin/get-newsletter.pl?LEAN&20051011&1;(Janury2008)

http://www.lean.org/Library/BatchProcessesByArtSmalley.pdf;(January2008)

http://www.worthsolutions.com/leanblog(February2008)

http://www.1000ventures.com/business_guide/supply_chain_mgmt.html;(February2008)

http://www.informit.com/articles/article.aspx?p=664147&seqNum=6;(March2008)

http://www.springerlink.com/content/x8q43554t522238h/;(March2008)

http://esd.mit.edu/WPS/ESD%20Internal%20Symposium%20Docs/ESD-WP-2003-01.04-ESD%20Internal%20Symposium.pdf;(April2008)

http://www.leaninstituut.nl/publications/1106/The_Heijunka_Box.pdf(April2008)

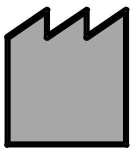
http://www.iswonline.com/ArticleLanding/tabid/67/Default.aspx?tid=1&ContentID=6723;(April2008)

http://www.valuebasedmanagement.net/methods_value_stream_mapping.html(May2008)

http://www.omnex.com/consulting/supply_chain.html(September2008)

Appendix

Value Stream Method symbols


customer
or supplier

stock
without defined
min/max values

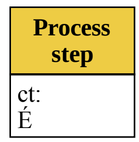

data processing
system


information flow


electronic data
exchange

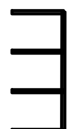

ãgo and seeÒ
production control


Kanban-collection
box/point

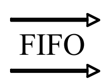


process step
(with value creation)


Transports
(material flow)

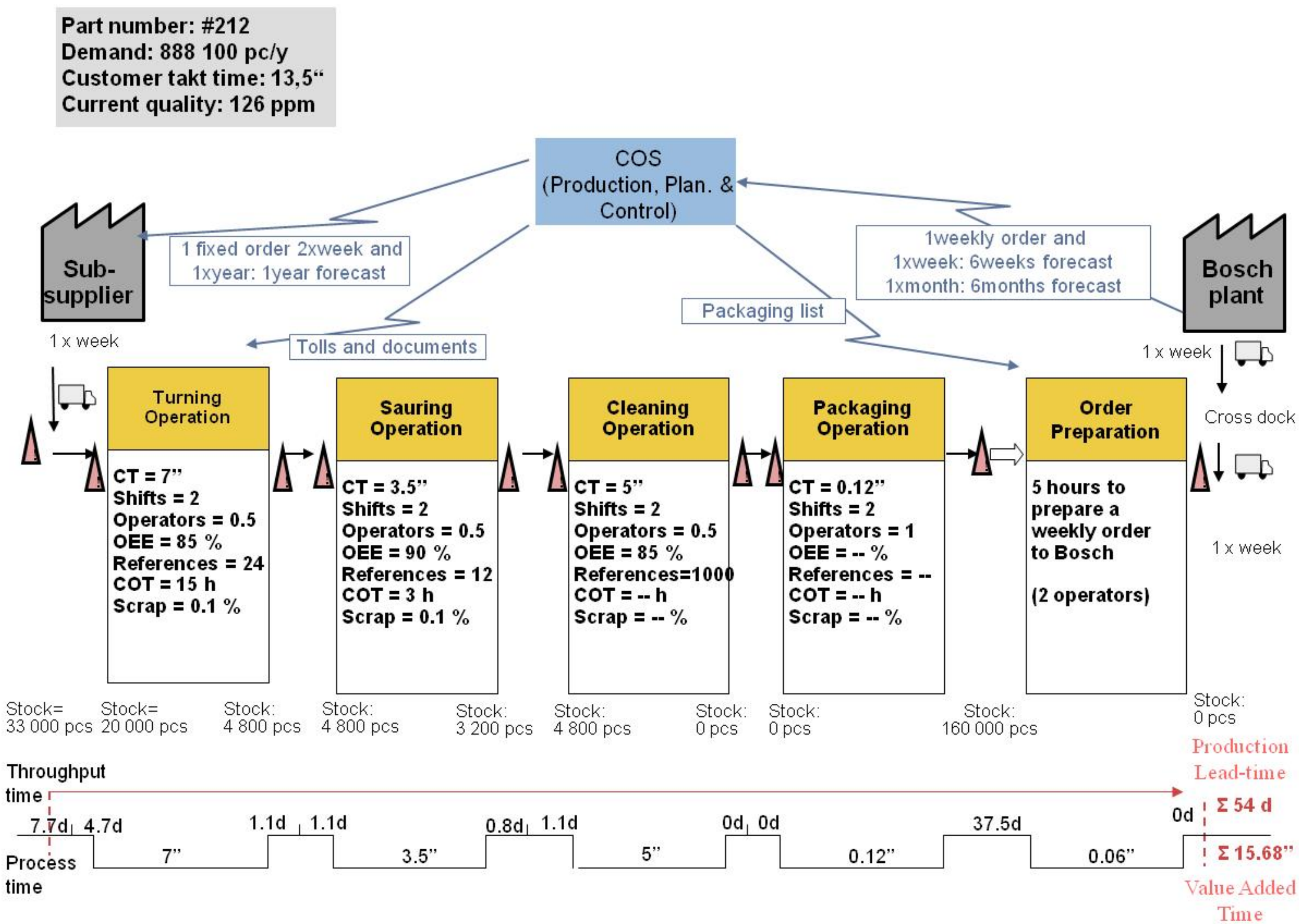

supermarket
with defined
min/max values


withdrawing
of material

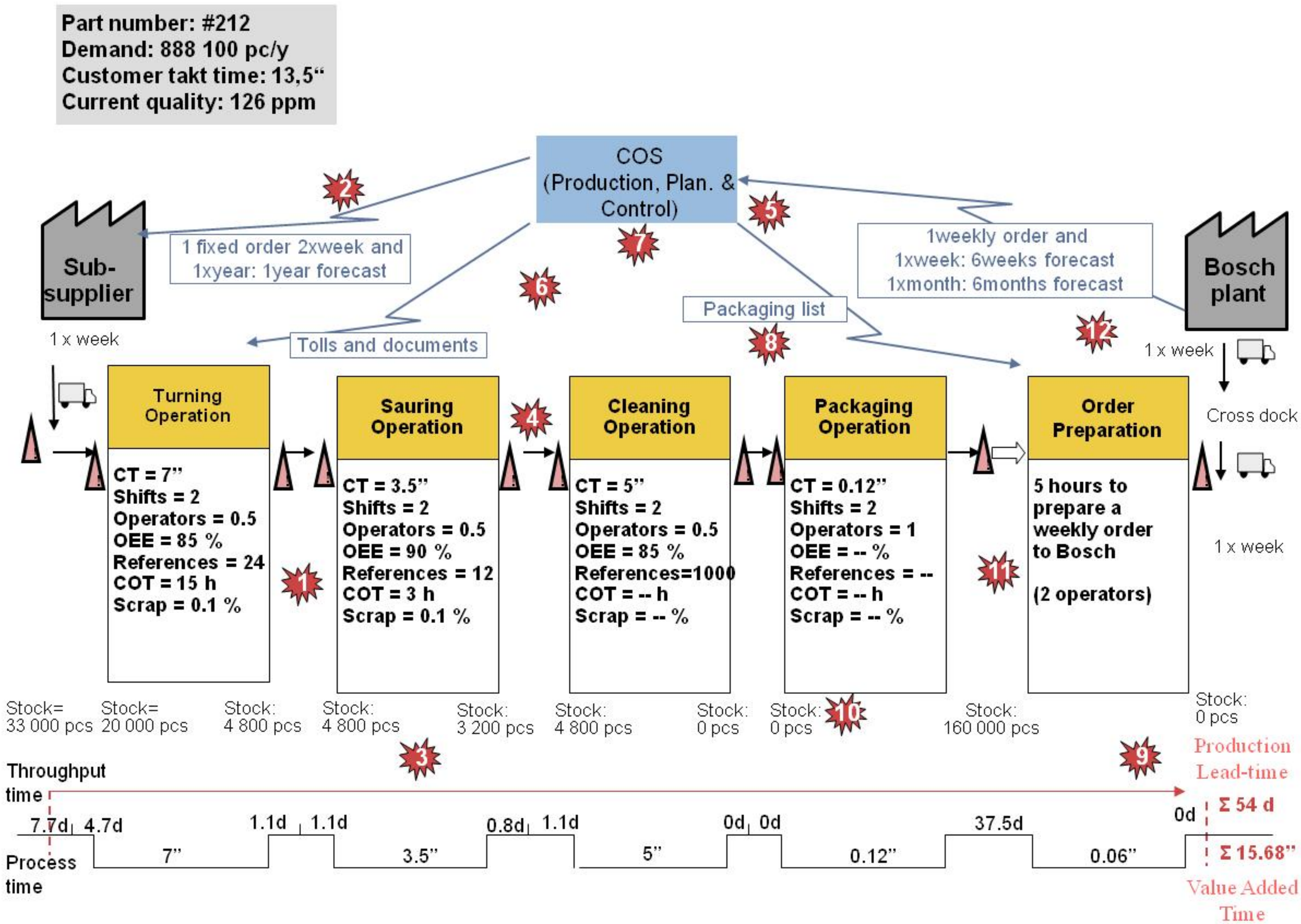


buffer with
first-in Ğfirst-out
realization and
defined min/max

COS Value Stream Mapping



COS Value Stream Mapping – Kaizen Flashes



Part Number Pull Selection

Part Number	Anual Consumption	Daily Consumption	Week Consumption	Consumption							Pull part	Batch Size	Max. Qt/box
				Week 0	Week 1	Week 2	Week 3	Week 4	Week5	Week 5			
8700306094	85580	389	1945	1702	1602	1594	1631	1562	1758	1402	OK	1000	1000
8703406107	50000	227	1136	118	107	172	204	198	123	154	OK	250	500
8700305178	**111350**	**506**	**2531**	**2361**	**1932**	**1806**	**2757**	**2522**	**2872**	**3011**	**OK**	500	1000
8700306221	427	2	10	0	10	0	0	0	0	0	NOK	50	200
8700306222	483850	2199	10997	10986	9233	10476	10371	12078	7986	11417	OK	2500	5000
8708202115	1170000	5318	26591	20392	28632	26543	10646	48134	14646	28343	OK	5000	5000
8700500064	7000	32	159	50	51	278	75	60	48	11	OK	100	500
8703406184	35500	161	807	837	741	863	949	864	725	768	OK	250	250
8708501316	43250	197	983	771	811	1009	939	836	1072	981	OK	500	500
8708202124	2806030	12755	63773	57772	55974	55244	68683	57550	56684	60174	OK	5000	5000
8703404222	300	1	7	0	0	1	0	0	0	0	NOK	10	100
8708502071	318322	1447	7235	7534	6598	6174	4840	6023	6773	6944	OK	1500	3000
8700305117	536	2	12	0	0	0	0	0	0	0	NOK	50	500
8700306092	25750	117	585	1303	696	379	406	953	136	150	OK	250	250
8703305349	19900	90	452	665	680	635	665	410	10	415	OK	50	200
8713407004	520	2	12	12	12	12	12	12	12	24	OK	10	100
8708202116	1146250	5210	26051	18049	26379	31314	20566	26248	24242	28128	OK	5000	5000
8703404212	**888100**	**4037**	**20184**	**14115**	**12876**	**19196**	**22609**	**22989**	**21645**	**19403**	**OK**	2000	4000
8708202167	85000	386	1932	0	56	40	18	8	11888	8	NOK	256	512
8708502036	**43200**	**196**	**982**	**1210**	**854**	**801**	**878**	**913**	**1093**	**858**	**OK**	500	1000
8703305350	18603	85	423	663	665	410	365	415	205	340	OK	50	100
8708501315	143990	655	3273	3385	3802	3232	4336	2976	3618	3542	OK	500	1000
8708501095	7500	34	170	136	101	163	189	184	271	124	OK	50	100
8708501235	3750	17	85	98	111	129	70	46	48	55	OK	50	100
8708502046	91470	416	2079	1821	2256	1930	2344	1457	1831	1902	OK	500	1000
8700305118	411500	1870	9352	8445	8659	9548	8210	9359	10052	9078	OK	1500	3000
8708202181	35800	163	814	12	12	24	12	5000	12	24	NOK	100	500